Vegetable Spiralism.

By George Macloskie.

My paper on Antidromy* attempted to show that every phenogamic plant produces two kinds of seeds, having their embryos turning in opposite directions, according to the side of the carpellary leaf on which they originated; also that the forthcoming plants have a primitive twist in opposite directions, showing itself in the histology of the stem, the dextrorse or sinistrorse phyllotaxy and anthotaxy, and in some cases in the structure of the carpels. The statement that the grains of Maize produce dextrorse or sinistrorse plants, according to the orthostichy of the ear in which they were produced, depended on hasty dissection; and although it seemed at first to be confirmed by the seedlings raised from the grains, I now find that there is no apparent constancy in this matter. My last experiment included nineteen seedlings grown from twenty grains taken in order from one of the paired rows in an ear (the row opposite my left hand) giving Nos. 1, 2, 3, 6, 8, 9, 10, 12, 15, 17, 20 with sinistrally overlapping leaves (Sc. the 1st leaf above the pileolus having its left margin external), and Nos. 4, 5, 7, 11, 13, 14, 18, 19 with dextrally overlapping leaves (No. 16 being abortive): thus giving eleven of one kind against eight of the other kind. In the grains from another homologous row, this proportion was nearly reversed. It is therefore necessary for the present to regard the beautiful symmetry of the ear of Maize (more beautiful in its early development than in its maturity) as a rearrangement of members at first as promiscuously arranged as are the staminate flowers of its panicle.†

Besides cases previously cited we have significant examples of antidromy in the seeds of *Salsola* (figured in Engler and Prantl, 3: 1a, 84. *Y*, *Z*), in the spirals of the Screw-pines, in the florets on the large head of the Sunflower and other large Compositae, which concur with the phyllotaxy, and even in the sword-like leaves of *Acorus Calamus*, those of one plant being dextrorsely

*Bulletin, 22: 379. Correct *erratum*, p. 380, three lines from foot, "distichous," so as to read "tristichous."

†I am obliged to the eminent agrostologist, Prof. W. J. Beal, for friendly criticism on this point.

twisted, and of another plant sinistrorsely. All the long leaves of all plants of *Typha* (both species) have a sinistral twist, in this showing no antidromy; but the mode of overlapping of the margins of their leaves near the nodes, which is the same for all the leaves of one plant, is contrary as between different plants. If this is a case of genuine antidromy, it is an argument against the view that the ovules of Typha arise terminally on the floral axis, a view which on other grounds has been doubted.

In the somewhat decussate leaves of *Paulownia*, and of the shaded branches of *Forsythia*, we can trace a spiral twist by following any one of the leaf orthostichies (they twist all in one direction about Princeton, where the plants are not propagated from seeds). But the branches of *Forsythia* when exposed to the sunlight lose their decussation and have all their leaves in two horizontal rows, thus demonstrating the controlling influence of the light. I believe that in a similar way many of our plants, as Elm, Beech and Morning-glory, have sacrificed their primitive phyllotaxy to the allurements of sunshine.

The Coniferae furnish an example showing how growth may supersede or even reverse the primitive order of parts. The young cones of *Picea*, *Tsuga* and other trees have the same spiral caste as the phyllotaxy, when we estimate their spirality by taking the longer of the two dominant curves as we do for the phyllotaxy. But after the cones open to give exit to the seeds, there comes a displacement of the scales, producing a false spirality in the contrary direction; thus the same tree, or even the two sides of a half-opened cone may present a quasi-antidromy. This may possibly be the explanation of published observations as to Conifers having antidromic cones on the same tree.*

The cases of *Arum*, *Iris* and *Juncus* were previously referred to as giving antidromic plants produced not by seeds but by division of the same rootstalk. A more curious case of diversity within the same plant is that of Bilsted (*Liquidambar Styraciflua*), which is cited in books as having opposite spirals in stem and branches. Every branch of this tree is true to its own phyllotaxy, with a $\frac{2}{5}$ divergence, dextrorse or sinistrorse for each, and this persisting through the annual innovations, whose crowded scale-scars

* *American Naturalist*, August, 1873.

are true to their phyllotaxy. In the horizontal members even the ridges of cork partially conform to the phyllotaxy of the particular member by a slight flexure to one side or the other. But the branches from the stem, or the branches from a branch do not necessarily conform to the phyllotaxy of the part from which they diverge; some of the daughter-branches may be homodromic, others heterodromic, as compared with the mother-branch, nor have I been able to discover any law in the case.

Perhaps these instances may favor the view that what we have in antidromy is not so much a special kind of heredity as an impulse depending on physical or nutritional causes, giving a bias to the young embryo or the young bud, which when once received is maintained. But whatever be the explanation offered, the facts are too important to be overlooked.

Sachs in his *History of Botany* treats Phyllotaxy as an exploded error, and gracefully celebrates its obsequies with the parting note that though wrong, it was useful in its day, adding "we would as little wish to omit it from our literature as modern astronomy would wish to see the old theory of epicycles disappear from its history." But what he and others condemned was an artificial or idealistic law imposed on plants in mathematical drapery; the twists that will naturally result from pressure upon young parts or from peculiarities of direction and of amount of nutriment, and from the modifying influence of light or climbing habits, are conceptions that were unknown to the fathers of mathematical phyllotaxy. From inattention to these considerations our botanists often miss what ought to be plain enough. Thus among the cryptogams Sachs gives us spores of *Equisetum* with a wrong spirality for their elaters (I confess my own sin here). Dodel-part gives oögonium of *Chara* wrong twisted; Engler and Prantl seem to require amendment as to *Erodium* (3: 4. 2) and as to *Halicteres* (3: 6. 93); and such instances may be multiplied.

Homodromic spiralism is not infrequent in phenogamic as well as in cryptogamic plants; as the dextrorse twining of some Leguminosae, of Convolvulaceae (including the Dodders) and of *Celastrus;* and other species are sinistrorse. Whilst it was shown in the paper on Antidromy that the mode of bursting of the car-

pels of Balsam is antidromic, in harmony with the phyllotaxy, we find that the carpellary "beaks" of *Geranium*, *Pelargonium* and *Erodium*, of the same natural order with Balsam, are all dextrorsely twisted. In these cases all the individuals of a species, or even of a suborder or order of plants, have the same kind of spiralism. But the leaves of all these are antidromic.

As a contrast to this we sometimes find a quasi-antidromy within the same plant, or even in the same carpel. Thus *Hibiscus* has the corollas of flowers on opposite sides of the same branch slightly contorted in contrary directions. The pod of the *Lotus corniculatus* and other Leguminosae bursts open through the forcible curving of its valves into antidromic spirals. The same occurs in *Joosia* of Rubiaceae (figure in Engler and Prantl, 4: 4. 46), and in the opening with a spring of the cocci of *Ricinus*. (A branch of this in fruit if left over night on a table may next morning have all its cocci opened and its seeds scattered about). Doubtless this is the dehiscing mechanism of the sandbox fruit of *Hura*.

The awns of Gramineae usually have secondary twists of functional significancy. In *Anthoxanthum* a brown dextrally twisted base is surmounted by a pale straight seta; in *Danthonia*, *Stipa*, etc., the base is a brown ribbon dextrally twisted, and this is surmounted by a rigid sinistrorse style. On the application of water the basal ribbon straightens out, causing the style to screw its way into the soil, into the wool of a sheep, or into the clothing and skin of man (witness Captain Cook's Crew in Australia in 1770). This kind of double twist may be termed *didromic* (as suggested by my colleague, Prof. Brackett). It is found in the setæ of some mosses (as figured by Sullivant, *Icones muscorum*, supplement), for example, *Funaria Americana*, *Pottiariparia*, *Rhynchostegium;* or some species of the mosses have the upper part of the seta dextrorsely, and others have it sinistrorsely twisted; but we do not see the significance of these peculiarities.

Charles Darwin showed that in some instances this didromic spirality is a physical necessity, as where tendrils must be shortened and yet their extremities are not to be rotated. This is the sort of spiral made by the cord-like scape of *Vallisneria spiralis*, so pulling down the fertilized carpel without having to

turn it round; and I find that in some plants of this species the upper section is dextrorsely spiral, and the lower section sinistrorsely, whilst in other plants these relations are reversed. Thus we have didromy within each plant of *Vallisneria* and antidromy between neighboring plants.

It would be dangerous at this stage to attempt generalizations as to the cyptogams. I may be permitted, however, to call attention to a few points. In the Atlases of Vegetable Palaeontology, by Schimper, Zeiler, Lesquereux and others, some of the figures of Carboniferous Acrogens, as Lepidodendron, Ulodendron, cones of Lepidostrobus, indicate a trend to one side which would indicate antidromy if others be found trending to the other side. The photograph of *Lepidodendron lycopodioides* in Plate LXX. of Zeiler's Atlas, does give a contrary spiral to that in Schimper's plates, but Zeiler's photograph may have been reversed in the process. The segments of apical cells of Hepaticae and Pteridophytes seem to indicate in some cases a direct or 'clock-wise' order of appearance, and in other cases a reverse order; but I do not know whether they may not vary in the same individual plant, or whether, on the other hand, they may not be homodromic in the totality of a species. I have been unable to find any variation of phyllotaxy in *Lycopodium* and allied forms, the great bilateral symmetry of the leafy axis obscuring the traces that might exist. But in two specimens of the tree-fern *Alsophila* the common phyllotaxy of $\frac{2}{5}$ can be made out at the apex of the stem; in both our Princeton specimens the spirality is dextrorse (that is, after the course of the thread of a common screw). If anybody can produce a specimen with sinistrorse phyllotaxy, he will thereby furnish the lacking evidentiary fact, and complete the proof of the antidromy of the ferns.

Botanical Notes.

Two new botanical Serials. One of our esteemed contemporaries has recently expressed some irritation on learning of the founding of a new serial publication. The number of opportunities for the publication of botanical papers is indeed great, but the supply of matter evidently exceeds the space provided, for we